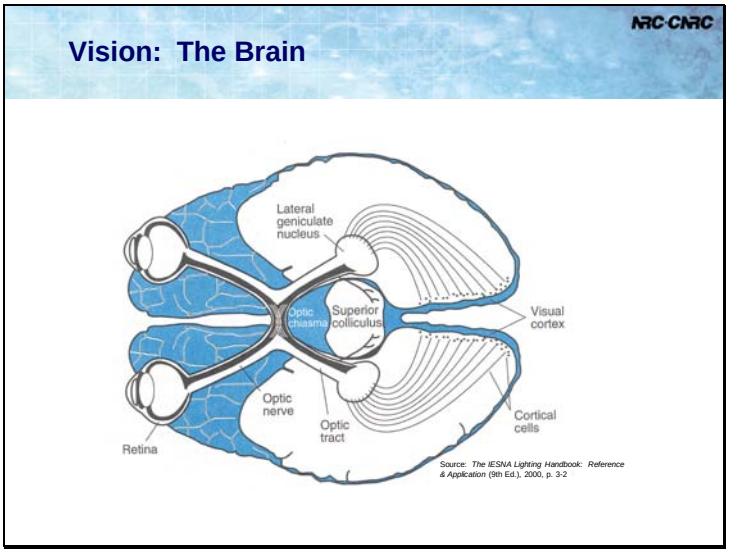
Slide 1

A presentation at "Voices for SSL Efficiency 2010" DOE SSL Market Introduction Workshop
Philadelphia, PA, July 22, 2010.

Slide 2

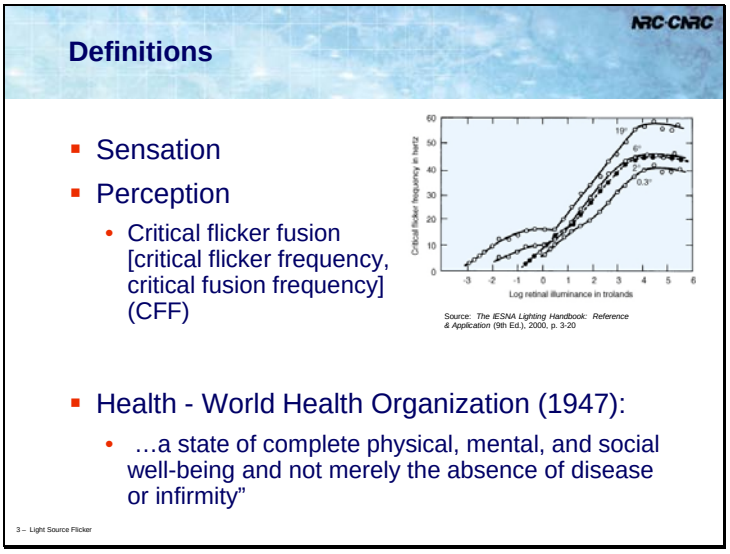


Light incident on the retina starts chains of electrochemical signals that carry information to other brain structures. Processing of visual signals starts at the retina. (There's also the second "non-image-forming" path involved in circadian regulation and other processes, as discussed in the morning session, but we're not concerned with that here.)

There is good evidence that fluctuations in the light signal are detected by the nervous system up to perhaps 200 Hz. Specifically, neurons in the lateral geniculate nucleus fire in phase with the fluctuations in the signal and retinal responses in the range of 120-200 Hz have been observed with varying methods.

For more information, see the IEEE PAR 1789 draft report at: http://grouper.ieee.org/groups/1789/ .

Slide 3



The neural measurements concern sensation: the detection of external conditions.

Perception is the process by which the brain interprets the sensory information.

In the case of flicker, the flicker will be perceived (i.e., it will be visible), at low frequencies but as the frequency increases there is a a point at which it will stop being perceived and the viewer will say that the light is constant. That point is called either 'critical flicker fusion' or 'critical flicker frequency'. The average rate at which people will stop reporting flicker is 60 Hz, but some people will report that they perceive flicker up to 90-100 Hz (the exact frequency varies from one person to another and in response to various conditions). CFF varies by many factors, both individual differences and within individuals in relation to fatigue, time of day, and health status. Above the CFF but up to about 200 Hz can occur flicker that is invisible (i.e. not perceivable) but detectable.

When we think about the health outcomes, we need to take into account the full range of outcomes and to bear in mind the WHO definition of health. We are not talking only about catastrophic outcomes, although those are important. We should be thinking about how to make a positive difference in the environment that people experience.

The flicker that is detected but not perceived has been shown to disrupt eye movements across text.

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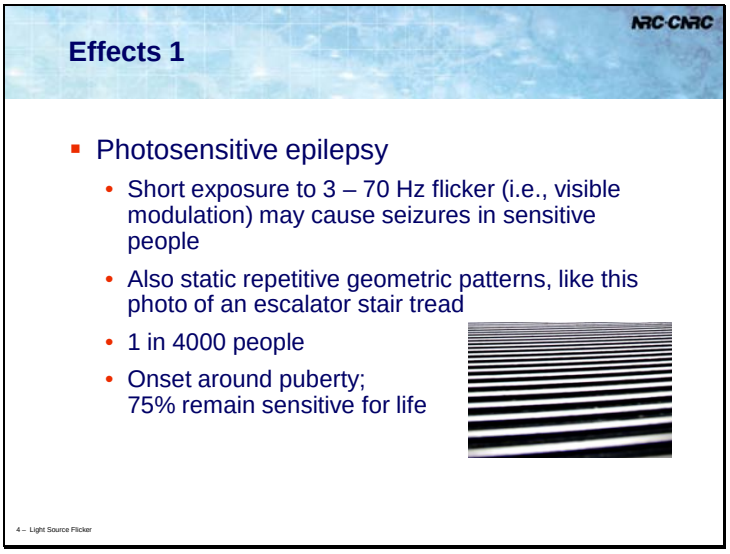
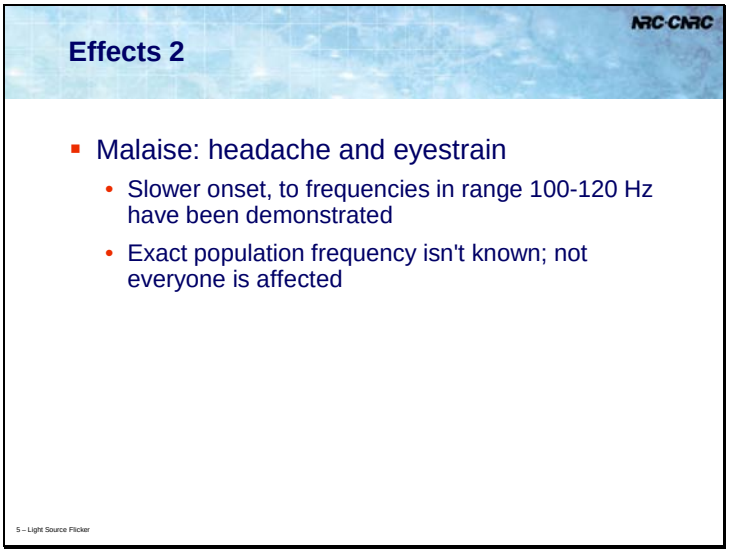


The catastrophic outcome that can occur in response to flicker is exemplified by epilepsy.

Slide 5



The evidence for this is primarily from comparisons of fluorescent ballasts, magnetic versus electronic. Since electronic ballasts became common research in this area has largely stopped; researchers lots interest because the problem seemed to have been corrected.

The common belief that fluorescent lighting causes headaches is probably partly related to this phenomenon, but might also reflect experiences with glare conditions.

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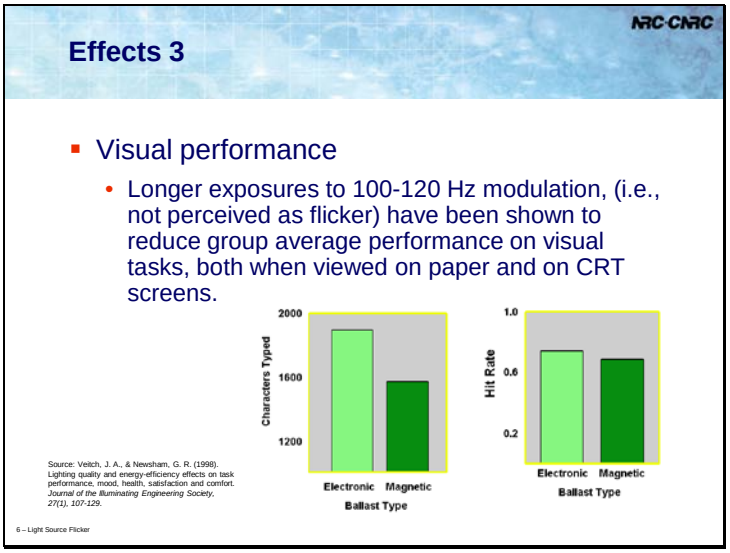

These two charts are from an experiment that my colleague Guy Newsham and I conducted several years ago now. There were 292 participants in all, ranging in age from 18 to over 60 (for this contrast, about 100 in the magnetic ballast group and about 200 in the electronic), and these results are for tasks performed after several hours in the space. All the tasks were on the same CRTs, which had the low refresh rates of the equipment that existed then; the difference between the groups relates to the room lighting.

The full paper is available at: http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc40663.pdf.

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Quality of the Evidence 1

- Why is there a potential problem, if I (or my clients) can't say the light is flickering?
  - Some effects develop after
    - several minutes of exposure
    - to modulation above the CFF but low enough in frequency for the nervous system's ability to respond
    - by people who are sensitive to it.

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Quality of the Evidence 2

- Who is affected?
  - Not all risk factors have been identified.
  - Younger people appear to be more at risk.

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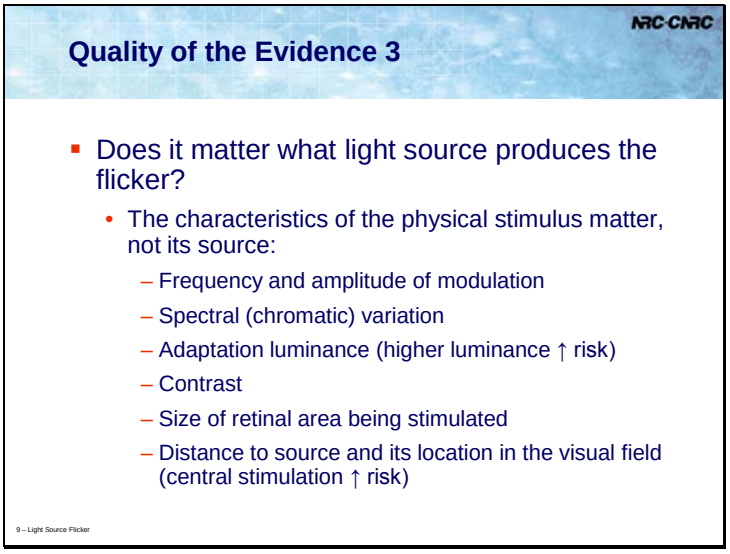

The eye doesn't care what the light source is; it responds to energy in the visible range (~380 to ~780 nm) of the EMF spectrum. The physical characteristics of the stimulus and the adaptation state of the system matter. Some of these dimensions come from the light source (e.g., the frequency and amplitude of modulation) and others come from the lighting installation and the task (the size of retinal area being stimulated, the distance to the source).

The larger the retinal area, the greater the risk of flicker-related problems.

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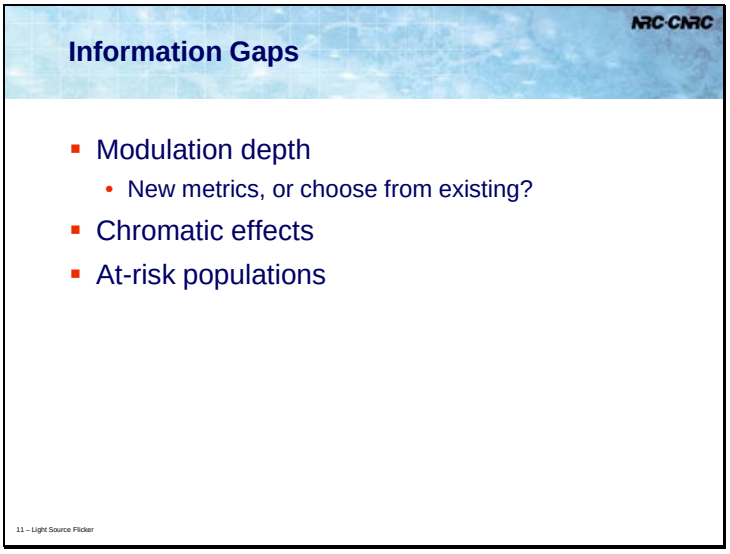
Quality of the Evidence 4

NRC·CNRC

- Is this only a problem for general room lighting?
  - Room lighting will cover a larger area of the visual field than some applications
  - …but, consider the nature of the visual task, e.g.,
    - a computer monitor taking up the whole visual field
    - the apparent flicker that arises from moving past a series of point sources (e.g., tunnel)

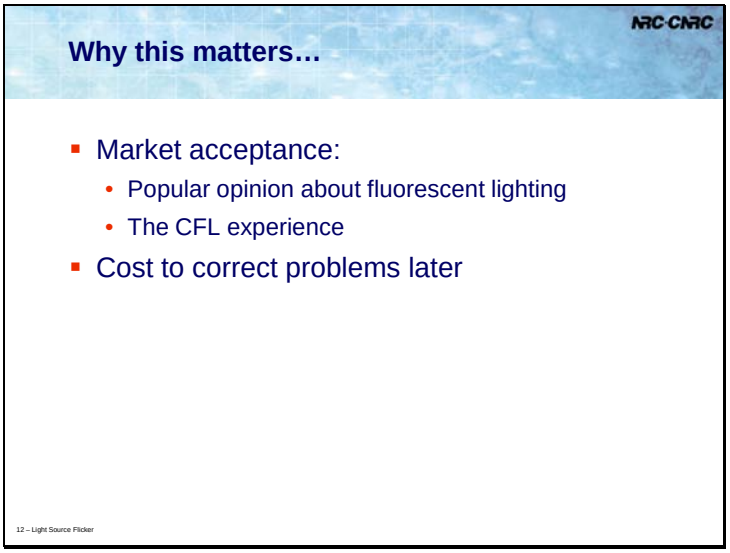
Slide 11



Frequency alone isn't the entire determinant of the effects discussed here; the depth of the modulation matters too, and possibly the shape. There is not good agreement about how to characterize flicker most usefully. This is a matter of discussion on PAR1789.

We are beginning to understand chromatic effects. Chromatic contrasts that are widely different from those found in natural scenes are more uncomfortable than those found in the natural environment.

Slide 12



Boyce (2003, p. 185): *"…a clear safety margin is necessary to avoid discomfort from flicker."*

No one wants to stifle innovation or to take designers' creativity from them; however, we have a unique opportunity right now to introduce revolutionary light sources to the world. The average person has a bias in favour of the familiar Edison lamp, but it's being taken out of service. The introduction of CFLs, as we know, foundered in part on a mishandling of the expectations and experiences of the general public. Paying attention to light source flicker while designing the next generation of SSL lighting is one piece of the puzzle in ensuring that they are widely accepted and successful in meeting our electric lighting requirements for years to come.

Let's not blow it; if there are technical solutions that can avoid the problem altogether, then let's use them. It's cheaper to design the flicker out now than to change it later.

Information:

- Compact Fluorescent Lighting in America: Lessons Learned on the Way to Market (http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/cfl_lessons_learned_web.pdf)
  - Performance is more important than appearance.
  - Education, of both consumers and retailers, is critical.
  - Consistent, meaningful terminology across the industry is important for new products.
- Structural equation modelling in lighting research: An application of new fluorescent lighting (http://lrt.sagepub.com/content/24/4/189.abstract)
  - Beliefs about (fluorescent) lighting can be divided into four distinct categories: cost and efficiency, negative qualities present while operating, negative qualities present only at start-up, and negative effects on people
  - The only belief category which has significant relationship to how much (fluorescent) lighting is liked is negative effects on people
- Assessing beliefs about lighting performance on health, performance, mood, and social behavior (http://eab.sagepub.com/content/28/4/446.abstract)
  - The adoption of new (energy-efficient) technologies will succeed only to the extent that the new technologies themselves are not perceived as risk sources.
- The psychology behind right light sources: review and research agenda (http://www.iaeel.org/IAEEL/archive/Right_light_proceedings/Abstracts/RL2_Abstracts/RL2Ab274.html)
  - Psychological influences include: perception, evaluation, memory, and comparison